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ABSTRACT

Two major topics are covered in this paper--the evaluation of instructional programs in general and the evaluation of computer-assisted instructional (CAI) course material during initial preparation. The first half of the paper reviews significant literature relating to instructional program evaluation and distinguishes between formative and summative evaluation. It then describes five models of evaluation, including three which specify procedures for the initial preparation of instructional programs, a fourth which represents a model for summative evaluation by an outsider, and a fifth which depicts several classes and data to be gathered during a comprehensive evaluation. The other major section of the paper deals with matters relating to CAI materials. Literature on the formative and summative evaluation of CAI programs is reviewed, followed by a discussion of consequential evaluation and an overview of some evaluative criteria. A model for CAI course preparation and evaluation is presented and recommendations for the inclusion of formative evaluation as an integral part of curriculum development are made. (Author/PB)

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SOME CONTEMPORARY MODELS FOR CURRICULUM EVALUATION

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A. Evaluation of Instructional Programs

1. Formative and Summative Evaluation

Authorities have referred to Cronbach's paper entitled "Course Improvement Through Evaluation" presented in 1963 as a "classic" (Glass, 1969). In this paper Cronbach defined evaluation as the "...collection and use of information to make decisions about an educational program" (Cronbach, 1963, p. 672). He indicated that such information could be used for course improvement, for decisions about individual students, or for administrative regulations. Cronbach emphasized the importance of evaluation for the purpose of course improvement:

> The greatest service evaluation can perform is to identify aspects of the course where revision is desirable... To be influential in course improvement, evidence must become available midway in curriculum development, not in the home stretch, when the developer is naturally reluctant to tear open a supposedly finished body of materials and techniques. Evaluation, used to improve the course while it is still fluid, contributes more to improvement of education than evaluation used to appraise a product already placed on the market (Cronbach, 1963, p. 675).

Cronbach stated that the analysis of performance on single test items or the record of responses to different types of problems could be more informative than an analysis of total scores. He viewed evaluation as:

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> ...a fundamental part of curriculum development, not an appendage. Its job is to collect facts the course developer can and will use to do a better job, and facts from which a deeper understanding of the educational process will emerge (Cronbach, 1963, p. 683).

Scriven (1967) proposed using the terms "formative" and "summative" to distinguish between evaluation to improve an instructional program or curriculum during its development and evaluation to determine the worth or effectiveness of an instructional program once it had been completed. He suggested that, in order to avoid potential clashes between curriculum writers and professional evaluators,

> ...formative evaluators should, if at all possible be sharply distinguished from the summative evaluators, with whom they may certainly work in developing an acceptable summative evaluation schema, but the formative evaluators should ideally exclude themselves from the role or judge in the summative evaluation (Scriven, 1967, p. 45).

Lindvall and Cox (1970) point out that, "Once a program has been developed and is fully functioning, the task of a summative evaluator is to describe just what that program does or what it is worth" (Lindvall and Cox, 1970, p. 56).

Scriven maintained that in the early stages of any kind of curriculum project general objectives or goals are formulated. These goals, which should not be considered absolute commitments, but rather reminders subject to alteration, might range from motivational and cognitive goals to the goal of producing a marketable program. Scriven declared that these goals were to be themselves items for evaluation; performance measured against goals was not to be the only

concern of the evaluator. To him it was "...obvious that if the goals aren't worth achieving then it is uninteresting how well they are achieved" (Scriven, 1967, p. 52).

Scriven outlined three types of activities which could facilitate both the evaluation of the goals and the evaluation of performance measured against those goals. These activities are:

1. Regular reexamination and modification of proposed general objectives or goals of the project.
2. Construction of a test-question pool, which thus becomes an "operational version of the goals" (Scriven, 1967, p. 56) and, as such, also requires regular reexamination and modification in light of any changes in the project goals.
3. External judgments about the consistency of the project goals, content, and test-question pool.

Scriven saw several refinements of the above activities as crucial to formative evaluation studies since they could uncover the causes of poor results:

> Essentially, we need to know about the success of three connected matching problems: first, the match between goals and course content; second, the match between goals and examination content; third, between course content and examination content. ...Only in this way are we likely to be able to track down the real source of disappointing results (Scriven, 1967, p. 59).

Stolurow in a paper presented at a Council for Exceptional Children Special Conference on Instructional Technology commented on the function of formative evaluation:

> It is the formative evaluation process that results in specific revisions of a program to improve its rhetoric, instructional effectiveness, and acceptability (Stolurow, 1970, p. 75).

In Handbook on Formative and Summative Evaluation of Student Learning, Bloom, Hastings, and Madaus defined evaluation as:

> ...the systematic collection of evidence to determine whether in fact certain changes are taking place in the learners as well as to determine the amount or degree of change in individual students (Bloom, Hastings, and Madaus, 1971, p.8).

They distinguished between formative and summative evaluation on the basis of purpose, time at which evaluation occurs, and "...level of generalization sought by the items in the examination used to collect data for the evaluation" (Bloom, Hastings, and Madaus, 1971, p. 61).

> We have chosen the term "summative evaluation" to indicate the type of evaluation used at the end of a term, course, or program for purposes of grading, certification, evaluation of progress, or research on the effectiveness of a curriculum... . Formative evaluation is for us the use of systematic evaluation in the process of curriculum construction, teaching and learning for the purpose of improving any of these three processes (Bloom, Hastings, and Madaus, 1971, p. 117).

In the Preface to their book the authors explained that their interest is the improvement of student learning, as the title of their book would indicate.

Airasian also focused on formative evaluation for the improvement of student learning. He stated that formative evaluation "...seeks to identify learning weaknesses prior to the completion of instruction on a course segment"

(Airasian, 1971, p. 79)...He summarized differences between formative and summative evaluation by indicating the verb tense used with each term: "...Formative evaluation provides data about how students are changing. Summative evaluation is concerned with how students have changed..." (Airasian, 1971, p. 78).

2. Models for Evaluation of Instructional Programs

In the following discussion five models for the evaluation of instructional programs will be described. The first three specify procedures for the initial preparation of instructional programs. The fourth represents a model for summative evaluation conducted by an outside evaluator. The fifth model depicts several classes of data to be gathered when conducting a comprehensive evaluation.

Model I. Stake (1967) indicated that two main types of information are necessary for the evaluation of educational programs. The first type is the intents and outcomes, and the second is personal judgments as to the quality and appropriateness of the intents and outcomes.

In another article Stake (1967) explained what his proposed evaluation program would involve. Descriptions of what intended antecedents or entry behaviors were expected, what intended transactions or instructional processes were planned, and what outcomes were anticipated would be evaluated for their logical relationship to each other. Then the descriptions of what actually happened would be examined to determine if what was intended actually occurred (see Figure 1). Finally, judgments of the value of the instructional program would be based on absolute standards reflected by the evaluator's personal judgment and on relative standards reflected by comparison of the particular program to alternative programs (see Figure 2). Program designers would prepare a rationale stating the basic purpose and philosophical background of their program which would assist the evaluators.

Stake posed five questions which he felt should be answered prior to the initiation of evaluation procedures:

"1. Is this evaluation primarily descriptive, primarily judgmental, or both descriptive and judgmental?

2. Is this evaluation to emphasize the antecedent conditions, the transactions or the outcomes alone, or a combination of these, or their functional contingencies.

3. Is this evaluation to indicate the congruence between what is intended and what occurs?

4. Is this evaluation to be undertaken within a single program or as a comparison between two or more curriculum programs?

5. Is this evaluation intended more to further the development of curricula or to help choose among available curricula?" (Stake, 1967, p. 539)

Stake here did not report the sequence in which the steps of his process would be followed, nor did he illustrate his process. No reports of projects in which his evaluation procedures had been used were located in the literature. Borich (1971) has suggested an expansion of the Stake model to increase the information yield about new educational products.

Model II. Briggs (1970) in his monograph entitled Handbook of Procedures for the Development of Instructional Systems presented a model for the preparation of new instructional course material. His model, which encompasses course design, development, and evaluation, provides for the deliberate selection or creation of instructional materials on the basis of both learner characteristics and the nature of the competencies which the course is supposed to develop, as well as on the basis of the characteristics of the material

alternatives (see Figure 3). The monograph is devoted to the design phase of Briggs' model. Briggs stated that formative evaluation procedures would start during the development and evaluation phases which he discussed briefly. He listed suggestions for formative evaluation which could be followed subsequent to what he called "formative design" steps taken during the development of first-draft materials in Steps 1-6. Briggs defined formative design as "...the use of performance tests (empirical data) for making the necessary decisions long before first-draft materials are ready for try-out" (Briggs, 1970, p. 173). In his critique of his model written after he and his graduate students had examined twenty other models for instruction drawn from military, industrial, educational, and governmental settings, Briggs observed several limitations in his model:

> The model is somewhat limited from the point of view of planning the integration of materials, space, teachers, and learners into an administrative and management system for the operation of the learning environment...Whereas the model may be inadequate for skills of inquiry needed for advanced types of problem solving, it is clearly useful as a guide for planning instruction at many of the less advanced levels (Briggs, 1970, p. 185).

Model III. Baker and Schutz declared, "Most instruction is dispensed, not developed" (Baker and Schutz, 1971, p. xv). They characterized instructional development as "...essentially a cyclical process, ...a team effort, and ... user-oriented" (Baker and Schutz, 1971, pp. xv-xvi). They viewed an adequate instructional development program as one giving consideration to five program systems: Instructional, Training, Installation, Accountability, and Modification.

The Instructional system in the opinion of Baker and Schutz is the key system from which specifications for the other four systems are derived. All systems share common characteristics and are closely interdependent, although each system has a distinct function within the total development program.

Baker and Schutz listed seven components of their instructional development cycle which cuts across all five program systems and system characteristics. These components are:

1. Formation
2. Instructional Specification
3. Item Tryout
4. Product Development
5. Product Tryout
6. Product Revision
7. Operations Analysis (Baker and Schutz, 1971, p. 131).

For each of the seven components in the development cycle Popham and Baker (1971) specified general rules (see Appendix A). In addition, Popham described principles demonstrated to be effective in following the rules for activities within each component of the development cycle. These principles are:

"1. Provide relevant practice for the learner.
2. Provide knowledge of results.
3. Avoid the inclusion of irrelevancies.
4. Make the material interesting" (Popham, 1971, p. 171).

To produce the interest required in the last principle listed above, Popham urged the deliberate use of variety, humor, game-type situations, suspense, and format variations.

Model IV. Glass (1972) applied a prototype evaluation format to the appraisal of an educational product already on the market, an instructional 100-foot

cassette tape recording of a presentation entitled "Evaluation Skills" given by Dr. Michael Scriven. The model covered the following items:

1. Product description
2. Goals evaluation
3. Clarification of point of entry of the evaluator
   a. Irreversible decisions
   b. Reversible decisions (Enter the evaluator.)
4. Trade-Offs
5. Comparative cost analysis
6. Intrinsic (secondary) evaluation
   a. Technical quality
   b. Content evaluation
   c. Utilization of uniqueness of medium
   d. Survey of availability
7. Outcome (primary) evaluation
8. Summative judgments and recommendations
9. Circumstances modifying the summative judgments (scope and value claims)

Glass's prototype model was prepared for the outside evaluator to follow in appraising a finished instructional product.

Model V. The CIPP model was developed by Stufflebeam and his associates at the Ohio State University. It might be regarded as a heuristic model for generating data classes. The CIPP Model has four components: Context, Inputs, Process, and Product (Stufflebeam, 1970).

Those four components should help provide relevant data to decision-makers.

First: Context - How will CAI fit into the overall plan of operation and the goals of the organization? How will present personnel react? What will their roles be? Will there be union problems? What about scheduling? Space?

Second: Input - What do the students bring to the learning situation? What are the desired entry behaviors? What prerequisite knowledge or skills are required?

Third: Process - What is the quality of interaction between student and system? How are individual differences accounted for? How well does the system match individual students with different instructional strategies? What are the testing procedures?

Finally: Product - Does the system work? Do all students meet all objectives? Are all relevant objectives covered? Are irrelevant objectives included? How much time is required? Are the students well prepared for whatever follows the program? How is student behavior changed? Is behavior changed in this context only? How long is the behavior maintained? Do students like the program? How about other personnel?

There is an extensive literature related to this model. Readers are referred to Dr. Don Stufflebeam, at the Evaluation Center, Ohio State University, for more information.

3. Summary

Authorities have distinguished between formative and summative evaluation and have developed models for authors of instructional programs to follow. Stake's plan for evaluation provides a general outline for instructional development projects which make evaluation an integral part of the project. Briggs' model places emphasis on the selection of available or the design of new materials in order for students to reach instructional objectives. Glass reports the results of his having used a model appropriate for the evaluation of finished products. Baker and Schutz outline a practical program for the newcomer in program development to follow.

Factors influencing the choice of a particular model would seem to include the purpose for and the scope of the evaluation, the point at which the evaluation is to be initiated, and the person to whom the task of evaluation is assigned.

B. Evaluation of Computer-Assisted Instruction Course Material During Initial Preparation

Rogers (1968) several years ago reviewed problems in CAI and observed that lack of quality CAI course material constituted a major problem. He called attention to the need for evaluated course materials.

Cartwright has identified recent trends in curriculum evaluation: evaluation is becoming acceptable and broader in base; as the contribution that formative evaluation can make to curriculum development receives greater recognition, there is a corresponding decrease in emphasis on summative evaluation; and in spite of this recognition, "...the large majority of CAI publications and papers that have become available in the last two years still are reporting summative evaluation activities..." (Cartwright, 1971, p. 2).

1. Formative and Summative Evaluation

Cartwright and Mitzel (1971) described both the formative and summative procedures they followed during the preparation of a three-credit CAI course designed for regular classroom teachers primarily in rural areas entitled "Early Identification of Handicapped Children." During the formative evaluation procedures, which covered approximately six months, fifteen students took the course while a proctor observed and recorded any student comments and program bugs. Technical problems went to the programer and content problems were given to the author who made necessary changes. Once all revisions had been organized, the course was revised and a second pilot group of fifteen students took the course unattended by a proctor. In addition, two graduate students in special education completed the course and submitted their evaluation reports. Then, 115 inservice teachers completed the course for college credit as a part of Penn State's Continuing Education program. Extensive

revisions were made as a result of the analyses of the responses, requests for assistance, and response latencies collected from these students. Finally, 300 more students completed the course and additional revisions were made as a result of data collected on those students. All told, over 333,000 student responses were analyzed during the formative evaluation.

To conduct a summative evaluation of the course, on-campus students who registered for "Introduction to the Education of Exceptional Children" were randomly assigned to conventional instruction (CI) and to CAI. Objectives for both courses were the same; in fact, the teacher of CI class had been one of the CAI course authors. Using time to complete the course and score on the 75-item final exam as variables, the authors reported that analyses of their data indicated the CAI students (n=27) scored significantly higher than CI students (n=87) on the final exam and completed the course in twelve hours less time than the CI students.

Confer (1970) reported another summative evaluation of a CAI course designed to teach general math. Students, all repeaters in general math, were randomly assigned to regular class instruction and to CAI instruction during a summer school session. Performance at the end of instruction in computation and problem-solving was measured with the Stanford Achievement Test (SAT). Analysis of covariance indicated no significant differences between the two groups on SAT scores. Confer concluded that his results neither confirmed nor rejected CAI as a method of instruction. Among his recommendations was the need for an analysis of all students' responses to help determine necessary changes in the CAI general math course.

In a speech at the Association for the Development of Instructional Systems in 1971, Cartwright stated:

> It is unlikely that summative evaluation per se will improve

> the quality of instruction. Formative evaluation, however, is a model that can be used to improve the quality of instruction. ...It seems to me that criterion-referenced instruction as a goal and formative evaluation as a method is the way to go at this point in time in the development of CAI (Cartwright, 1971, p. 9).

2. Consequential Evaluation

Glass (1969) has described consequential evaluation as follows: "Consequential evaluation is evaluation of the affects (sic) of the program... (the consequences of the program)" (Glass, 1969, p. 5). Formative evaluation deals with data collection for the purposes of improving the course and summative evaluation is concerned with the "comparative worth or effectiveness of competing programs" (Glass, 1969, p. 5). Consequential evaluation is concerned with a more slippery criterion -- long range performance or behavior of the learners who have taken the CAI program. In the case of CAI programs in teacher education, we are concerned with the performance of teachers in the classroom and, ultimately the behavior of the children in those classrooms. Good consequential evaluation studies are quite expensive to carry out and quite difficult to manage.

3. Criteria for Evaluation of CAI

Seltzer has written:

> What the computer can and cannot do is a matter of research and fact. What the computer should and not do in instruction is based on value judgments...(Seltzer, 1971, p. 373).

Seltzer suggested that, in order to be in a position to make value judgments, criterion statements should be drawn up for use in evaluating the selection of the computer to assist in any particular instructional process. The

criterion statements Seltzer proposed are:

"1. If the computer poses a unique solution to an important problem in the instructional process, then it should be used regardless of the cost involved.

2. If the computer is more efficient or effective and the cost of its use to instruct is minimal, then it should be used. And conversely,

3. If the cost of development and use of the computer in instruction is relatively high with the relative efficiency or effectiveness only marginal, then the computer should not be used in the instructional process" (Seltzer, 1971, p. 375).

These criterion statements look at CAI cost, effectiveness, and efficiency in comparison to alternative means of instruction. They could logically be considered during the initial design of a proposed CAI application to instruction before much instructional material had been developed.

4 Model for CAI Course Preparation and Evaluation

Bunderson constructed a prescriptive model for the design of CAI course material. He explained the circumstances which prompted his effort:

> The instructional design model described in this chapter was originated to provide management and quality control for curriculum development, to provide a bridge between the curriculum development and basic research activities of the laboratory, and to serve as a focus for teaching students and others how to design quality CAI programs. Its development was influenced by the author's attempts to adjust to a joint appointment between educational

psychology and computer science and to communicate with staff members and students from both fields (Bunderson, 1970, p. 46).

Bunderson discussed the activities to be performed by the instructional designer, their approximate sequence, and the product of each activity. The design activities in the sequence Bunderson outlined are:

1. Intent and justification
    a. Write societal needs.
    b. Write institutional needs.
    c. Write program goals.
        1. Describe job requirements.
        2. Describe student population.
        3. Describe institutional constraints.
    d. Write justification for CAI.
2. Instructional design: analysis
    a. Derive operational requirements from goals.
        1. Derive terminal objectives.
        2. Set entering performance standards.
        3. Consider effect of constraints on program design.
    b. Behavioral analysis
        1. Obtain intermediate objectives through analysis of terminal objectives.
        2. Construct learning hierarchy.
    c. Analysis of learner traits
3. Instructional design: synthesis
    a. Specify interface.

1. Display and response devices.

2. Representation.

b. Construct individualizing flow chart.

1. Hierarchy-based gating mechanisms.

2. Trait-by-treatment branches.

3. Continuously adaptive mechanisms.

c. Write working draft.

1. Construct curriculum-embedded tests controlling major flow.

2. Write steps and describe format of steps.

4. Produce program materials.

a. Code from author's draft.

b. Produce media.

c. Debug code and proof media.

5. Evaluate and revise.

a. Editorial evaluation.

b Internal empirical evaluation.

c External empirical evaluation.

1. Validation testing.

2. Longitudinal validation.

6. Use of feedback.

Return to any previous step as indicated by evaluation, revise, and recycle.

In his discussion of parts of his model, Bunderson observed that the construction of a learning hierarchy (see above, 2.b.2.) seems ...

> ...readily applicable to any cumulative subject matter such as mathematics, much of science, and even music. It seems less applicable to highly verbal areas (Bunderson, 1970, p. 56).

5. Summary

A survey of the literature related to both evaluation and CAI reveals that models for formative evaluation are available for use in developing course materials, that authorities urge formative evaluation be incorporated into initial CAI course development projects, and that to date formative evaluation procedures have not been reported in many completed projects. In the one model designed specifically for CAI course preparation, the author observed that some of the activities he outlined were more suitable for subject matter with inherent structure rather than for highly verbal subject matter on which several structures might be imposed.

Authorities continue to stress the need for formative evaluation during initial CAI course preparation for purposes of course improvement. They see little information in summative evaluation results that can help authors locate course weaknesses or errors.

The application by a course author of a formative evaluation model to the initial preparation of a CAI course would seem strongly indicated.

APPENDIX A

A REVIEW OF PRODUCT DEVELOPMENT RULES
(Baker and Schutz, 1971, pp. 167-68)

FORMULATION

F:1. The extensiveness of a proposed product's justification should be communsurate with the importance of the product.

F:2. Excessive time should not be spent in formulation.

F:3. In justifying the development of the new product, make certain there are no competing products of high quality.

INSTRUCTIONAL SPECIFICATIONS

IS:1. All instructional objectives should be stated in terms of the learner's post-instructional behavior.

IS:2. En-route and entry behaviors should also be described behaviorally in the instructional specifications.

IS:3. Criteria for judging the adequacy of the learner's response should be specified.

IS:4. A clearly specified method for determining learner affect toward the completed instructional product should be specified.

ITEM TRYOUT

IT:1. The criterion test must be completely prepared prior to the development of the instructional product.

IT:2. Measures of the entry and en-route behaviors should be constructed during the item tryout stage.

IT:3. Prototype items should not deviate from the behaviors described in the instructional specifications.

IT:4. Prototype items should be tried out with a small number of learners first, later with a larger number of learners.

PRODUCT DEVELOPMENT

PD:1. Supply the learner with appropriate practice during an instructional sequence.

PD:2. The product should provide the learner with the opportunity to obtain knowledge of results.

PD:3. The instructional product should contain provisions for promoting the learner's interest in the product.

PD:4. Avoid the development of an inflexible strategy in approaching product development tasks.

PD:5. If teachers are involved in the instructional process, make their participation as replicable as possible.

PD:6. In general, adopt a "lean" programming strategy.

PD:7. If the product is to be used in the classroom, develop it so that teacher attitudes toward the product will be positive.

PD:8. Selection of the instructional medium should be made in light of the desired instructional objectives, intended target population, cost, and other relevant considerations.

PD:9. The time devoted to the development of the product should be commensurate with the importance of the product.

PRODUCT TRYOUT

PT:1. Avoid an extremely small or extremely large number of learners when field testing the product.

PT:2. Verify that the procedures associated with the use of the product result in a replicable treatment.

PT:3. Data from field trials should be efficiently summarized for use by those who will revise the product.

PT:4. Those involved in field testing the product should collect data; they should not, themselves, engage in drawing inferences from the data.

PRODUCT REVISION

PR:1. Base product revisions on legitimate inferences from field test data.

PR:2. The primary inferences regarding product revisions should be made from criterion data.

PR:3. Learner response data during the program should be considered a valuable source of cues for product improvement.

PR:4. No loss of face for the initial developer should be associated with revisions of an instructional product.

OPERATIONS ANALYSIS

OA:1. Operations analysis should be performed at the conclusion of all systematic development of instructional products.

OA:2. The operations analysis should be written and transmitted to some central repository.

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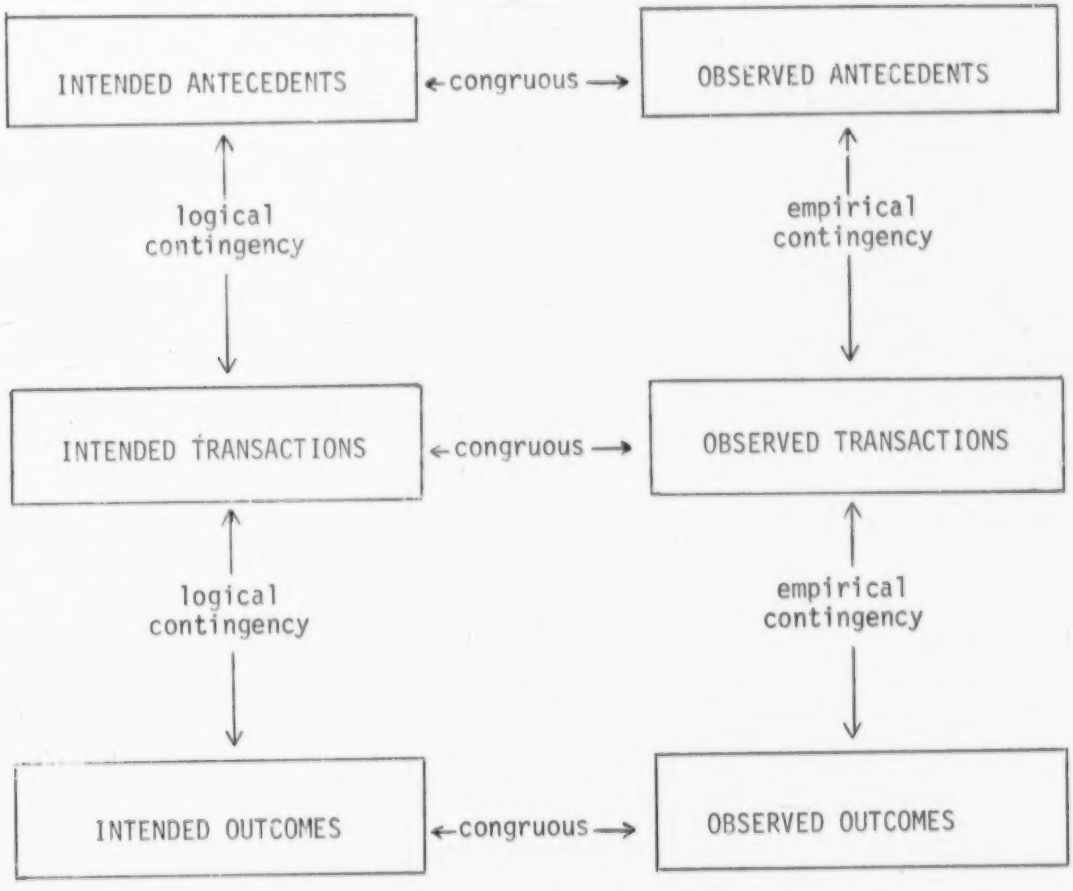
FIGURE 1

A REPRESENTATION OF THE PROCESSING
OF DESCRIPTIVE DATA[a]



[a]Stake, Robert E. The countenance of educational evaluation. Teachers College Record, April, 1967, p. 533.

FIGURE 2

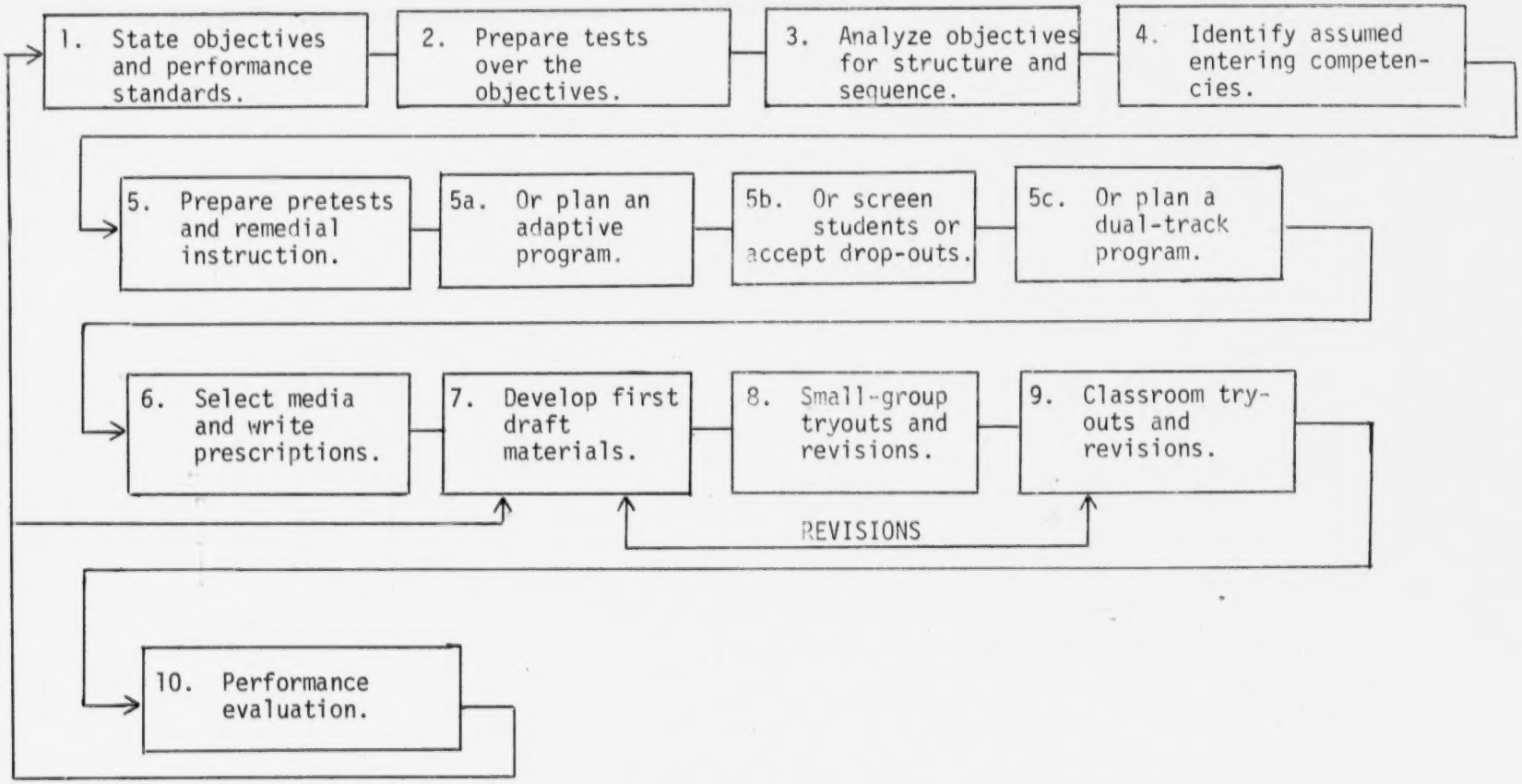
A REPRESENTATION OF THE INTERRELATIONSHIP OF DESCRIPTIVE AND JUDGMENT DATA[a]

	DESCRIPTIVE MATRIX		JUDGMENT MATRIX	
	Intents	Observations	Standards	Judgments
Antecedents				
Transactions				
Outcomes				

[a]Stake, Robert E. The countenance of educational evaluation. Teachers College Record, April, 1967, p. 532.

FIGURE 3

FLOW CHART: A MODEL FOR THE DESIGN OF INSTRUCTION[a]


1. State objectives and performance standards.
2. Prepare tests over the objectives.
3. Analyze objectives for structure and sequence.
4. Identify assumed entering competencies.
5. Prepare pretests and remedial instruction.
5a. Or plan an adaptive program.
5b. Or screen students or accept drop-outs.
5c. Or plan a dual-track program.
6. Select media and write prescriptions.
7. Develop first draft materials.
8. Small-group tryouts and revisions.
9. Classroom try-outs and revisions.
REVISIONS
10. Performance evaluation.
Additional Revisions of Materials and/or Objectives and Performance Standards.

[a]Briggs, Leslie J. Handbook of procedures for the design of instruction. Pittsburgh: American Institutes for Research, 1970, p. 7.